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RESEARCH MEMORANDUM

MEASUREMENT OF THE DYNAMIC LATERAL STABILITY OF THE DOUGLAS D-558-1 AIRPLANE (BUAERO NO. 37971) IN RUDDER KICKS AT A MACH NUMBER OF 0.72

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SUMMARY

In the course of a stability and control investigation of the D-558-1 airplane, rudder kicks were made at a Mach number of 0.72 at a pressure altitude of 8500 feet. The lateral oscillations resulting from the rudder kicks required $1\frac{1}{2}$ seconds to damp to half amplitude and had a period of 1.1 seconds. The Navy requirement which specifies the damping of lateral oscillations was satisfied by a small margin. The oscillation damps completely leaving no residual constant amplitude oscillation. The yawing oscillation produces an oscillation in pitch which apparently is caused by the gyroscopic moment of the engine.

INTRODUCTION

The NACA is engaged in a flight research program in the transonic speed range utilizing the Navy procured D-558-1 airplanes. One of these airplanes is being used for the investigation of stability and control characteristics. References 1 to 3 present the results of research previously reported on this airplane. The present paper gives the results of two rudder kicks made at a Mach number of 0.72.

SYMBOLS

H	pressure altitude, feet
M	Mach number corrected for position error
n	normal acceleration in g units

F_e, F_a, F_r elevator and aileron wheel forces, and rudder-pedal force, pounds

$\delta_e, \delta_a, \delta_r$ elevator, aileron, and rudder positions, degrees

β sideslip angle, degrees

C_{N_A} airplane normal-force coefficient (Wn/qS)

W airplane gross weight, pounds

S wing area, square feet

q dynamic pressure, pounds per square foot

AIRPLANE

The Douglas D-558-1 airplane is a single-place low-wing airplane powered by a General Electric TG-180 turbojet engine. General views of the airplane are given as figure 1 and a three-view drawing of the airplane is given as figure 2. Detail specifications of the airplane are given in reference 1.

INSTRUMENTATION

Standard NACA instruments were used to measure the various quantities necessary to determine the stability and control characteristics of the airplane. Quantities recorded were airspeed, altitude, three components of acceleration, rolling angular velocity, sideslip angle, aileron and elevator wheel forces and rudder-pedal force, aileron, elevator, rudder, and stabilizer positions. All the records were synchronized by a common timer.

RESULTS AND DISCUSSION

Rudder kicks have been obtained at a Mach number of 0.72 at a pressure altitude of 8500 feet. Time histories of these rudder kicks, presented in figure 3, show that the oscillation resulting from the rudder kick is damped, damping to half amplitude in about $1\frac{1}{2}$ seconds,

with a period of about 1.1 seconds. Although the period is short, the damping satisfies the Navy requirement given in reference 4 by a small margin. This requirement is presented with the experimental data as figure 4. For comparison, the old flying-qualities requirement, which specified that the lateral oscillation damp to half amplitude in not more than 2 cycles, is also presented in figure 4.

The oscillation damps completely with no constant amplitude residual oscillation as encountered with the X-1 airplane (reference 5). Reference 3 shows a lateral unsteadiness at high Mach numbers, but it is believed that this is caused by aileron control movements necessary to counteract an intermittent wing heaviness at high Mach numbers.

The variation of normal acceleration during the lateral oscillation is believed to be caused by the gyroscopic action of the engine.

CONCLUSIONS

Data obtained from rudder kicks with the D-558-1 airplane at a Mach number of about 0.72 indicate the following conclusions:

1. The lateral oscillation has a short period of 1.1 seconds and damps to half amplitude in about $1\frac{1}{2}$ seconds. The damping satisfies the Navy requirements by a small margin.

2. The oscillation damps completely with no residual constant amplitude oscillation.

3. The yawing oscillation produces an oscillation in pitch apparently because of the gyroscopic moment of the engine.

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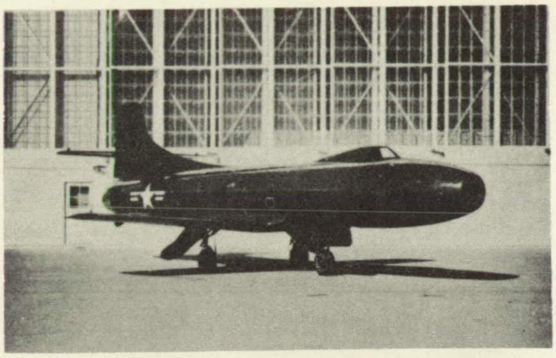
2. Williams, Walter C.: Flight Measurement of the Stability Characteristics of the Douglas D-558-1 Airplane (BuAero No. 37971) in Sideslips. NACA RM No. L8E14a, 1948.

3. Barlow, William H., and Lilly, Howard C.: Stability Results Obtained with Douglas D-558-1 Airplane (BuAero No. 37971) in Flight up to a Mach Number of 0.89. NACA RM No. L8K03, 1948.

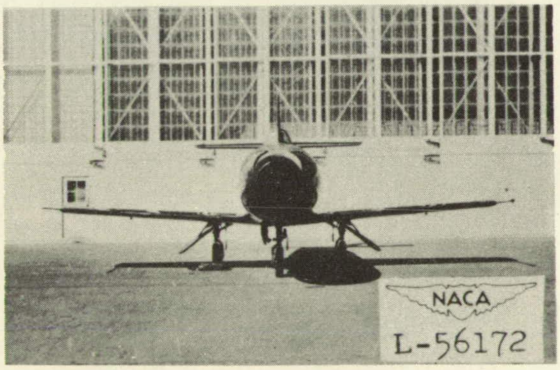
4. Anon.: Specification for Flying Qualities of Piloted Airplanes. NAVAER SR-119B, June 1, 1948.

5. Williams, Walter C., Forsyth, Charles M., and Brown, Beverly P.: General Handling-Qualities Results Obtained during Acceptance Flight Tests of the Bell XS-1 Airplane. NACA RM No. L8A09, 1948.

(a) Side view.



(b) Three-quarter front view.



(c) Front view.

Figure 1.- Photographs of D-558-1 airplane.

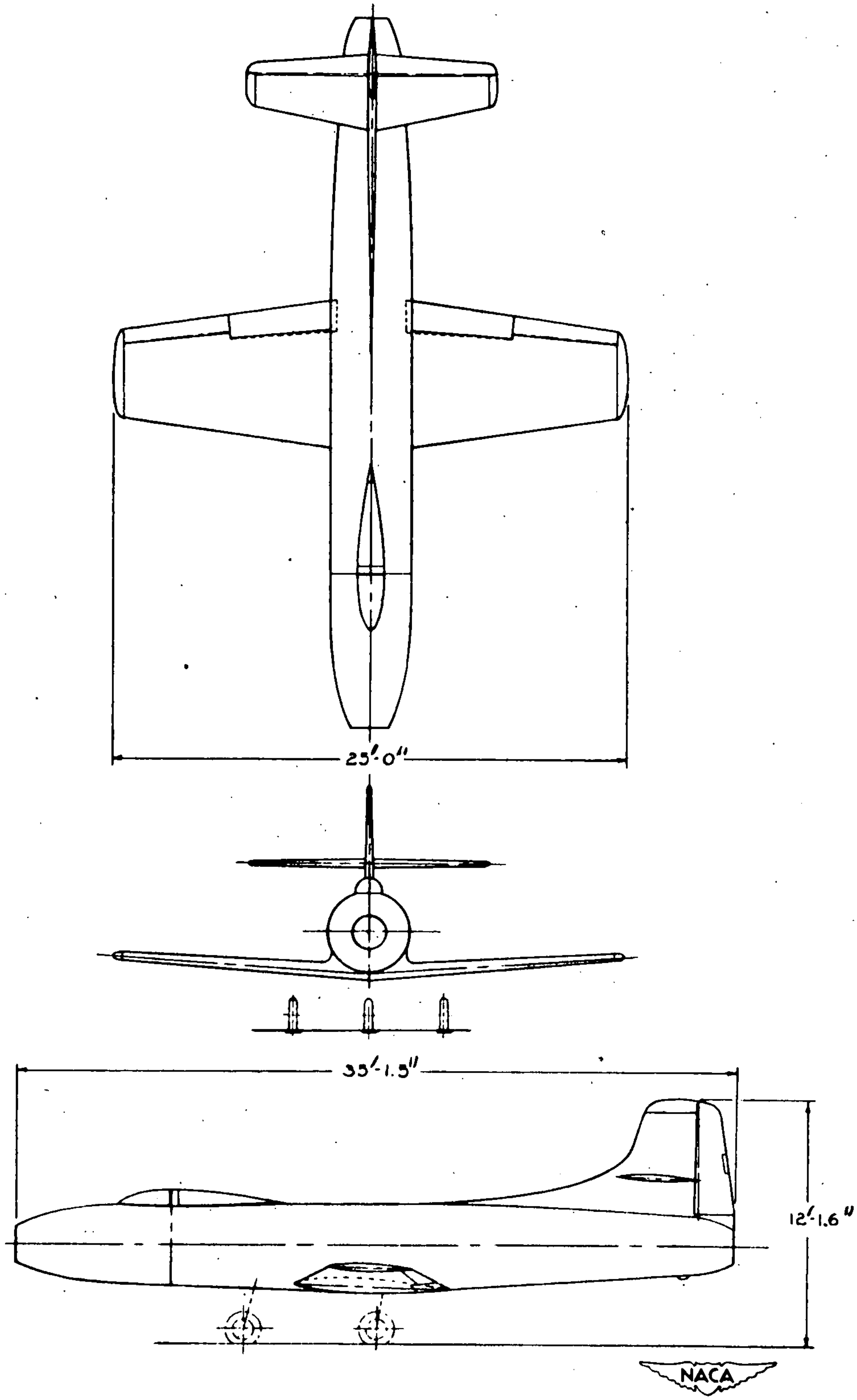


Figure 2.– Three-view drawing of D-558-1 airplane.

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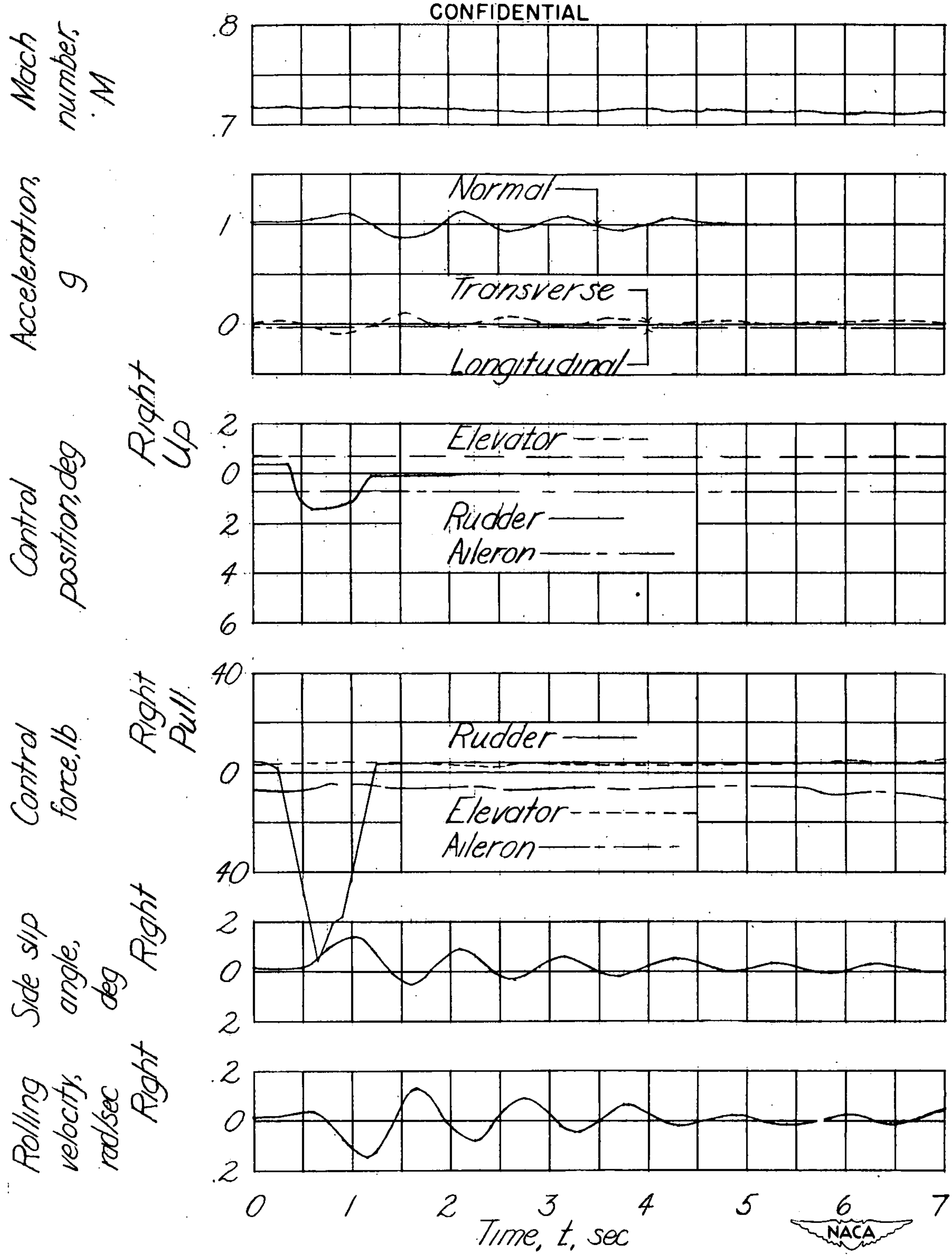

Figure 3.– Time histories of rudder kicks made with D-558-1 airplane. Pressure altitude = 8700 ft; C_{N_A} = 0.12.

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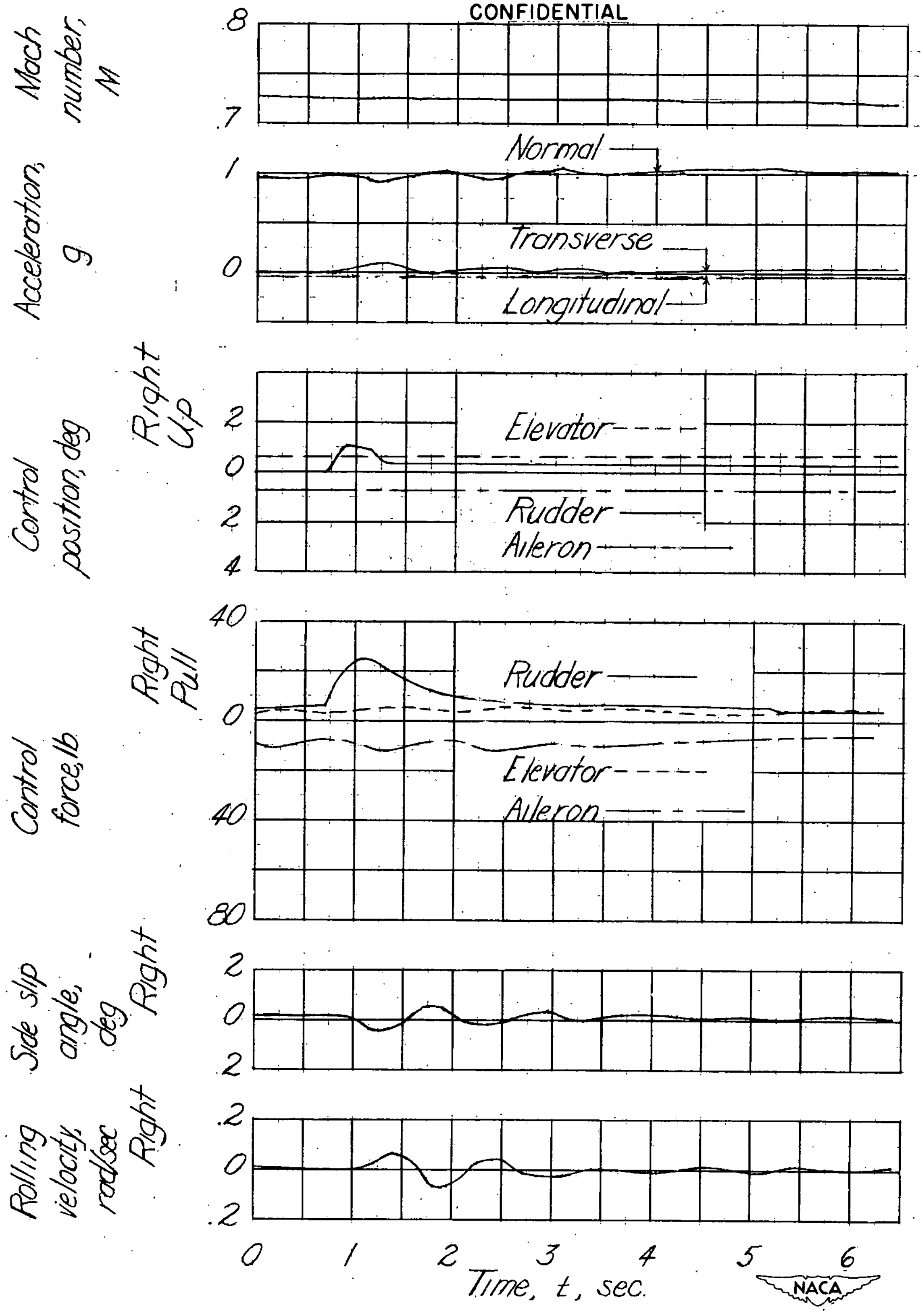

Figure 3.– Concluded.

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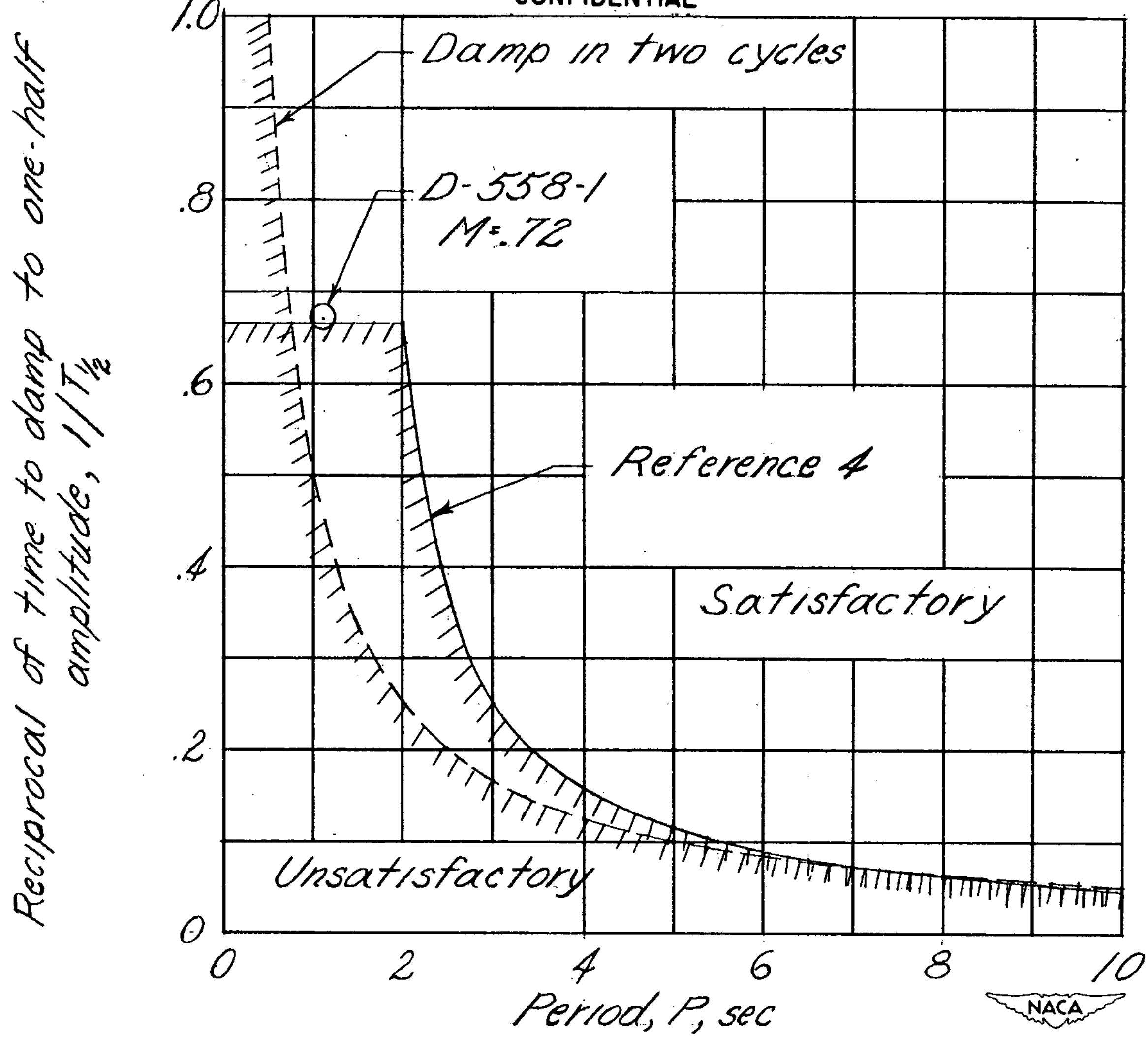

Figure 4.- Measured damping of D-558-1 as compared with the Navy SR-119B requirements for satisfactory damping of the lateral oscillation.

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